Biological and Physical Research Enterprise (BPRE)

Mission

NASA's Office of Biological and Physical Research (OBPR) conducts interdisciplinary fundamental and applied research to pursue answers to the basic questions underlying human space flight:

- How can human existence expand beyond the home planet to achieve maximum benefits from space?
- How do fundamental laws of nature shape the evolution of life?

The microgravity environment of space allows scientists to open a new window on the most basic and important biological, chemical, and physical processes. At the same time, the space environment poses major challenges to the well-being of space travelers. Space flight exposes humans to low gravity and radiation environments never before encountered in our evolutionary history. As we seek to exploit the rich opportunities of space flight for fundamental research and commercial development, we must develop efficient and effective technologies and methods for protecting human health in space.

Goal 1: Conduct research to enable safe and productive human habitation of space.

OBPR conducts fundamental and applied research in the biological and physical sciences to reduce the health risks of space travel. We conduct research on technology for efficient, self-sustaining life-support systems to provide safe, hospitable environments for space exploration, and develop advanced technologies for healthcare delivery. Advances in healthcare first developed for the space flight environment are applied on Earth to enhance healthcare.

Goal 2: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.

The space environment offers a unique laboratory in which to study biological and physical processes. Researchers take advantage of this environment to conduct experiments that are impossible on Earth. For example, most combustion processes on Earth are dominated by the fact that hot gases rise. In space, this is not the case, and hidden properties of combustion emerge. Materials scientists study the role of gravity in important industrial processes. Physicists take advantage of microgravity to study exotic forms of matter that are better handled in space. Biological researchers investigate the role of gravity in life processes and how the space environment affects living organisms. The knowledge derived from OBPR's diverse research will inform and expand scientific understanding, support economic and technological progress, and help to enable human exploration of space.

Goal 3: Enable and promote commercial research in space.

OBPR provides knowledge, policies, and technical support to facilitate industry investment in space research. OBPR will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The commercial sector

will grow to become the premier mechanism for applying space knowledge to benefit the American people. Commercial applications of space knowledge will generate new products, new jobs, and new spin-off companies.

Goal 4: Use space research opportunities to improve academic achievement and the quality of life.

OBPR seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond. We deliver value to the American people by facilitating access to the experience and excitement of space research. OBPR strives to involve society as a whole in the transformations that will be brought about by research in space.

Resource Requirements

(NOA, dollars in millions)

	FY1999	FY 2000	FY 2001	FY 2002
$M	$263.5	$274.7	$312.9	$360.9
CS FTE	420	382	372	484

With the formation of a new Biological and Physical Research Enterprise, resource requirements for annual performance goals are somewhat more transparent. Each annual performance goal is associated with a specific program budget; however, the majority of OBPR performance goals are overarching and interdependent in nature. They are not budgeted as discrete elements of OBPR programs.

Implementation Strategy

OBPR's program is implemented at seven NASA Field Centers and the Jet Propulsion Laboratory, as well as through the participation of Commercial Space Centers (CSCs), a National Space Biomedical Research Institute, and a National Center for Microgravity Research on Fluids and Combustion. OBPR relies upon an extensive external community of academic, commercial and government scientists and engineers for the implementation of its programs. OBPR-supported science and technology research projects are reviewed by scientific or technical peers. In selecting investigations and projects to support—and ultimately for access to space—OBPR follows peer-review processes appropriately designed for scientific research, technology research and development, and commercial research. Our peer review processes ensure the competitiveness and quality of OBPR research.

OBPR implements its research programs through ground-based as well as flight research. Ground-based research precedes flight research and employs NASA facilities such as drop towers, centrifuges, and bed-rest facilities. The flight research programs use the full spectrum of platforms, including free-flying satellites, Space Shuttle, and now ISS.

Roadmap: [Source: NASA Strategic Plan]

Near–term Plans (2000-2005)	Mid-term Plans (2006-2011)	Long-term Plans (2012-2025)
• Identify mechanisms of health risk and potential physiological and psychological problems to humans living and working in space, and begin developing and testing countermeasures. • Conduct scientific and engineering research and enable commercial research activities on the ISS to enrich health, safety, and the quality of life on Earth. • Begin developing interdisciplinary knowledge (e.g., biology, physics, materials) to support safe, effective, and affordable human/robotic exploration.	• Understand the effects of long-duration space flight (e.g., radiation), validate countermeasures and technology and begin developing countermeasures for long-duration space flight. • Extend our understanding of chemical, biological, and physical systems. • Test and validate technologies that can reduce the overall mass of human support systems by a factor of three (compared to 1990's levels).	• Apply and refine countermeasures for safe, effective, and affordable long-duration human space flight. • Achieve a deep understanding of the role of gravity in complex chemical, biological, and physical processes. • Test and validate technologies for safe, self-sufficient, and self-sustaining life support systems that can enable humans to live and work in space and on other planets for extended periods.

OBPR is preparing for the transition to a new era in human space flight. The International Space Station (ISS) will provide a growing capability as a research platform. OBPR will work to extract the maximum scientific and commercial return from this promising research facility while conducting research to ensure the health and safety of space travelers in the near term and into the future.

Performance Measures

OBPR will conduct interim evaluations and monitoring of performance targets at midyear and at the end of the fiscal year. OBPR will present progress on each annual performance goal to its NASA Advisory Committee subcommittee, the Biological and Physical Research Advisory Committee. This committee will evaluate progress toward each annual performance goal and assign a qualitative score of red, yellow, green, or blue, with blue indicating outstanding progress, green indicating satisfactory progress, yellow indicating poor or partially satisfactory progress, and red indicating unsatisfactory progress.

Goal: Conduct research to enable safe and productive human habitation of space.

Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

Millions of years of evolution have molded the human body to cope with and rely upon gravity. Virtually every system of the body responds when a person travels to space. Weight-bearing bones lose about 1% of bone mass per month. Muscles atrophy, and nerves in the balance system begin to rewire their connections to take account of the sudden disappearance of up and down. Many of these changes pose significant health issues, especially when space travelers return to gravity. NASA research will identify methods that will efficiently control the effects of space travel and ensure the health and safety of future space travelers.

Public Benefit: The primary goal of this research is to improve health and safety for space travelers; however, this research also has the potential to make significant contributions to medical care on Earth. For example, space flight can provide models for exploring osteoporosis and other diseases of muscle and bone. It has provided unique insights into nerve regeneration and the capacity of the nervous system to grow, change, and adapt in response to environmental stimuli. The parallels between aging and space travel are currently under study by researchers at NASA and the National Institutes of Aging. OBPR has used the Critical Path Roadmap to link indicators under this Performance Goal to the Agency's longer-term objectives in this area of research.

Annual Performance Goal 2B1: Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators:

- Identify and test biomedical countermeasures that will make space flight safer for humans.
- Identify and test technologies that will enhance human performance in space flight.

Performance Indicators:

- Complete protocols for flight testing countermeasure to reduce kidney stone risk.
- Develop an investigation of crew nutritional needs and metabolism status.
- Prepare in-flight validation of cardiovascular countermeasures.
- Evaluate and provide annual report of the progress in reducing medical risk factors.

Public Benefit: Humans can only travel to space by bringing a microcosm of the Earth with us. We need an atmosphere, food, water, and protection from temperature extremes and space radiation. NASA research will develop advanced technologies for efficient life support systems to provide these needs with minimal resupply from Earth. These technologies will reduce the cost of space travel and may find application in process control systems for industry, and even in helping to provide clean environments in homes, vehicles, and offices.

Annual Performance Goal 2B2: Earn external review rating of “green” or “blue” by making progress in the following research focus area:

- Identify and test new technologies to improve life support systems for spacecraft.

Performance Indicators:
- OBPR will demonstrate, through vigorous research and technology development, a 33% reduction in the projected mass of a life support flight system compared to the current (FY 2001) system baselined for ISS. The quantitative calculation of this metric will be posted on the Internet.
- Complete a radiation protection plan that will guide future research and development to improve health and safety for space travelers.

Objective: Conduct research on biological and physical processes to enable future missions of exploration.

Basic research in the biological and physical sciences is an essential precursor to future advanced technologies and systems for supporting a human presence in space. Beyond reducing the cost and increasing safety for space travelers, this basic research promises to push the frontiers of knowledge and technology for Earth applications.

Public Benefit: Our collaborative effort with the National Cancer Institute will support the future development of next-generation instruments for molecular-level diagnostics for space and Earth application. Basic insights into biological and physical mechanisms behind physiological changes in space will support the future of human presence in space while adding to the store of biomedical knowledge that underlies medical care on Earth.

Annual Performance Goal 2B3: Earn external review rating of “green” or “blue” by making progress in the following research focus areas:
- Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring.
- Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers.

Performance Indicators:
- Collaborate with the National Cancer Institute to create and maintain a core program using academic, industrial, and government researchers to develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical processes.
- Develop a study on the effects of space flight on bone loss as a function of age in an animal model.
- Develop studies on space-flight-induced genomics changes.

Goal: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

Gravity's influence is everywhere. From the structure that gives steel its strength, to the structure of bone in a growing child, gravity plays a role. Researchers can only eliminate the effects of gravity in space. In space, we can study how gravity has shaped life on Earth and how living things respond to its absence. In space, we enter a new realm of research in physics, chemistry, and biology. NASA conducts research in focused areas with the potential to improve life on Earth. We rely on the advice of the Space Studies Board of the National Research Council, as well as the NASA Advisory Committees and associated cross-disciplinary task groups to set the strategic direction of the program.

Public Benefit: Research on complex physical and biological systems has the potential to benefit industrial applications in optical computing and communications, pharmaceutical packaging, food manufacturing, cosmetics, and polymer manufacturing.

Annual Performance Goal 2B4: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators:

- Advance the scientific understanding of complex biological and physical systems.

Performance Indicators:

- Prepare an ISS research investigation on colloidal physics.
- Maintain a peer-reviewed research program in Complex Systems physics and chemistry.

Public Benefit: This biotechnology research may have applications in structural biology, rational drug design, and artificial tissues engineering for medical applications.

Annual Performance Goal 2B5: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators:

- Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.

Performance Indicators:

- Maintain a peer-reviewed research program in macromolecular and cellular biotechnology.
- Prepare ISS research investigations in protein crystallization and three-dimensional tissue culture.

Public Benefit: Space flight provides a unique environment for fundamental research in fluid physics and materials science which supports human space flight and produces valuable insights into industrial processes on Earth. Integrating fluid physics and materials science with fundamental biology provides unique new research capabilities that will be implemented by an interdisciplinary program with access to space.

Annual Performance Goal 2B6: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators:

- Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology.

Performance Indicators:

- Initiate the definition of a Bio-science and Engineering institute to drive novel concepts for space-based investigations in biomolecular systems.

Public Benefit: This basic research has the potential to substantially enhance the accuracy of our time-keeping standard, support development of ultra-precise Global Positioning System time measurements, and support the development of molecular-based medical diagnostic devices.

Annual Performance Goal 2B7: Earn external review rating of "green" or "blue" by making progress in the following research focus area:

- Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.

Performance Indicators:

- Maintain an outstanding and peer-reviewed research program in condensed matter physics, Bose-Einstein Condensation, and atomic clocks development for space-based utilization.
- Produce scientific discoveries in atomic and condensed matter physics, and publish in mainstream peer-reviewed archival journals.
- Design and develop flight experiment apparatus for low-temperature physics, laser cooling, and atomic physics investigations on the ISS.

Public Benefit: This research has the potential to support advances in energy production efficiency, combustion products emission control, advanced materials manufacturing, and the chemical engineering industry.

Annual Performance Goal 2B8: Earn external review rating of "green" or "blue" by making progress in the following research focus area:

- Investigate fundamental and unresolved issues in fluid physics, and materials and combustion science using gravity as a theoretical and experimental revealing tool.

Performance Indicators:

- Maintain an outstanding and peer-reviewed program in fluid physics, and materials and combustion sciences.
- Complete the preparation for ISS investigations in fundamental materials science to be carried out in the Microgravity Science Glovebox.
- Prepare two major space-based combustion research experiments for flight on the Space Shuttle.
- Initiate a new annual process to solicit and select peer-reviewed, ground-based investigations in materials science, fluid physics, and combustion research.

Public Benefit: This basic research has the potential to support improved medical care and agricultural performance by strengthening our basic understanding of biological processes.

Annual Performance Goal 2B9: Earn external review rating of "green" or "blue" by making progress in the following research focus area:

- Understand the role of gravity in biological processes at all levels of biological complexity.

Performance Indicators:

- Maintain an outstanding and peer-reviewed program in fundamental space biology.
- Develop and implement Fundamental Space Biology research plans to utilize early ISS capability.
- Determine baseline data requirements for model specimens to be used on ISS.
- Plan for incorporation of baseline data collection in ISS hardware validation flights.

Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

Space flight opportunities for biological and physical research are very scarce. OBPR develops strategies and approaches to enhance flight opportunities and to support a balanced research program so as to maximize scientific return.

Public Benefit: By working with the scientific community, OBPR seeks to maximize scientific return from space flight opportunities.

Annual Performance Goal 2B10: In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.

Performance Indicators:

- Assume management responsibility for the ISS research budget.
- Begin procurement activities leading to a Non-Governmental Organization for Space Station Research.
- Coordinate scientific community participation in the definition of ISS research.
- Balance resource allocations and flight opportunities through a Partner Utilization Plan.
- Prepare peer-reviewed and commercial research investigations for execution on STS-107.

- Conduct early research on the International Space Station.

Goal: Enable and promote commercial research in space.

Objective: Provide technical support for companies to begin space research.
Objective: Foster commercial research endeavors with the International Space Station and other assets.

Ultimately, the solutions to the challenges of human space flight will open up new avenues of commerce. Even now, dozens of commercial firms conduct small-scale research projects in space. OBPR provides knowledge, policies, and technical support to facilitate industry investment in space research. OBPR will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The commercial sector will grow to become the premier mechanism for applying space knowledge to benefit the American people. Commercial applications of space knowledge will generate new products, new jobs, and new spin-off companies.

Public Benefit: The benefits of commercial research in space include improved products and services to enhance economic performance on Earth. In the long-term, economic activity in space will provide strengthened infrastructure for the exploration and development of space.

Annual Performance Goal 2B11: Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators.

Performance Indicators:
- Maintain or increase non-NASA investment in commercial space research during the FY 2002 transition from a Shuttle-based to an ISS-based program.
- Maintain a ratio of non-NASA funding to NASA funding of not less than 3:1 in FY 2002.
- Ensure that one of the 39 product lines currently under investigation is brought to market, available for commercial purchase, in FY 2002.
- Enable at least 10 new, active industrial partnerships to be established with the Space Product Development Commercial Space Centers.

Objective: Systematically provide basic research knowledge to industry.

Public Benefit: Conducting outreach to the commercial community extends the benefits of commercial research to the broadest set of participants and strengthens the contributions of commercial research for the development of space.

Annual Performance Goal 2B12: Highlight ISS-based commercial space research at business meetings and conferences.

Performance Indicators:
- Support at least 3 business/trade conferences to highlight ISS-based commercial space research.

Goal: Use space research opportunities to improve academic achievement and the quality of life.

Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

Public Benefit: OBPR seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond.

Annual Performance Goal 2B13: Provide information and educational materials to American teachers.

Performance Indicators:

- Develop electronic and printed educational materials which focus on biological and physical research, and distribute these materials at at least three conferences and through the Internet.

Objective: Engage and involve the public in research in space.

Public Benefit: OBPR delivers value to the American people by facilitating access to the experience and excitement of space research. OBPR strives to involve society as a whole in the transformations that will be brought about by research in space.

Annual Performance Goal 2B14: Work with media outlets and public institutions to disseminate OBPR information to wide audiences.

Performance Indicators:

- Work with PBS and Discovery Channel producers to explore opportunities for TV products with space/research/microgravity themes.
- Work with Life Science Museum Network members to explore opportunities for the development of projects, special events, or workshops focused on Life Sciences biology-related research themes to attract and engage public audiences.
- Make available to wide audiences an online database of Commercial Space Center activities, including publications listings, patents, and other information useful to the public.

Verification/Validation

OBPR cooperates with NASA's Inspector General during an annual review of the accuracy of our reporting process. The Life and Microgravity Sciences and Applications Advisory Subcommittee is not expected to independently confirm the accuracy of data presented by OBPR. Rather, the Committee's role is to assess progress based on the data that OBPR presents and apply its expert judgement to produce an evaluation. The Office of the Inspector General selects a subset of targets for detailed audits to determine the accuracy and reliability of OBPR's data on performance targets.

Annual performance goals 2B1 through 2B9 are fundamentally qualitative in nature and the committee will have broad discretion in assigning scores on these goals based on performance indicators as well as other information. Annual performance goal 2B2 is evaluated using a novel formula developed by OBPR's Advanced Human Support Technology program. Details of this process are available for review on the program's website at http://ADVLIFESUPPORT.JSC.NASA.GOV/ under the title "Advanced Life Support Metric Document".

Annual Performance Goals 2B10 through 2B14 are more readily evaluated using objective criteria as established in their associated indicators.

MULTI-YEAR PERFORMANCE TREND
Biological and Physical Research Enterprise (BPRE)

Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H29: Perform component and subsystem ground tests without humans in the loop to demonstrate advanced technologies, including biological water processor, and flight test a new electronic "nose" sensor on a chip.	0H31: Complete the first phase (including outfitting three test chambers) of the Advanced Life Support System Integration Test Bed facility that will provide the capability to conduct a series of long duration, human-in-the-loop, advanced technology tests over the next six years. Demonstrate key technology capabilities for human support, such as advanced techniques for water processing using microbes, waste processing using biological degradation and fluidized bed incineration, a no-expendable trace gas contaminant control system, solid waste processing, and flight test of a miniature mass spectrometer.	1H18 Demonstrate, in ground test, at least one technology that could reduce up to 25% of life support logistics over ISS baseline and release report of progress for review on the Internet.	2B2 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Identify and test new technologies to improve life support systems for spacecraft.
Assessment	Green	Green	TBD	TBD

Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H25 Complete the development of countermeasure research protocols, and begin testing a minimum of three countermeasures intended to protect bone, muscle, and physical work capacity. H6 Publish a report defining the time course adaptations in the balance system to altered gravitational environments. H10 Document Mir radiation research data to facilitate ISS EVA planning. H7 Document Mir data lessons learned to facilitate ISS biomedical and countermeasure research.	0H26 Develop medical protocols and test the capability of the Crew Health Care System as integrated in the ISS U.S. Laboratory. 0H25 Evaluate and develop for flight testing a minimum of three major research protocols intended to protect bone, muscle, and physical work capacity and prepare a minimum of 10 biomedical research experiments, (utilizing the capabilities of the STS and ISS HRF) to study human responses to the gravitational environment.	1H17 Develop new biomedical and technological capabilities to facilitate living and working in space and safe return to Earth. 1H31 Initiate implementation of the Bioastronautics Initiative by beginning a NASA /NCI collaboration and conducting a peer review of NSBRI to assess expansion.	2B1 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Identify and test biomedical countermeasures that will make space flight safer for humans. • Identify and test technologies that will enhance human performance in space flight.
Assessment	Green	Green	TBD	TBD

Objective: Conduct research on biological and physical processes to enable future missions of exploration..

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H5 Publish a report of comparison of 3 different biological models to understand the influence of gravity on the nervous system. H8 Document Mir data lessons learned to facilitate ISS research in fundamental biology and regenerative life support.	0H33 Complete Radiation Research Instrument for Mars 2001 mission to study transit, orbital, and surface radiation effects and conduct three workshops to define and prioritize research tasks in subjects such as radiation shielding materials, in situ resource utilization, and fluids management and heat transfer technology. Complete the science definition of granular flows, flight, and dust management experiments to begin gathering research data to alleviate critical problems of dust buildup, habitat foundation engineering, and rover performance during planetary exploration.	1H31 Initiate implementation of the Bioastronautics Initiative by beginning a NASA /NCI collaboration and conducting a peer review of NSBRI to assess expansion.	2B3 Earn external review rating of "green" or "blue" by making progress in the following research focus areas: • Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring. • Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers.
Assessment	Green	Green	TBD	TBD
APG	H26 Initiate a collaborative program to design and develop instruments		1H1 Complete testing and delivery for spacecraft integration of experiments for the Mars Surveyor Program 2001 missions.	
Assessment	Green		TBD	

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	FY 2000	FY 2001	FY 2002
APG				2B4 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Advance the scientific understanding of complex biological and physical systems.
Assessment				TBD
APG	H9 Analyze Mir data to achieve a 3-year jump-start for cell culture and protein crystal growth research and document analyses & lessons learned.			2B5 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.
Assessment	Green			TBD

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	FY 2000	FY 2001	FY 2002
APG				2B6 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology.
Assessment				TBD
APG				2B7 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.
Assessment				TBD

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H13 Use data obtained by fluid physics experiments on suspensions of colloidal particles on MSL-1 to answer fundamental questions in condensed matter physics regarding the transition between liquid and solid phases and publish data on the transition from liquids to solids and the results in peer-reviewed open literature. H11 Improve predictive capabilities of soot processes by at least 50% through analysis of MSL-1 data; publish results in peer-reviewed open literature. H12 Use MSL-1 results to eliminate one of the three primary fluid flow regimes from consideration by casting engineers, and publish this result in peer reviewed literature. Casting engineers may use this information to improve metal casting processes in industry.	0H11 Using suborbital rockets, complete one combustion experiment on the flame spread of liquid fuels to better control Earth/space-based fire hazards, and conduct one investigation to test theories of fundamental physics properties and physical laws of fluids to provide key data for earth and space-based processing materials; report the results.		2B8 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Investigate fundamental and unresolved issues in fluid physics, and materials and combustion sciences using gravity as a theoretical and experimental revealing tool.
Assessment	Green	Red		TBD

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	FY 2000	FY 2001	FY 2002
APG				2B9 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Understand the role of gravity in biological processes at all levels of biological complexity.
Assessment				TBD

Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

APG				2B10 In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.
Assessment				TBD
APG		0H26 Develop medical protocols and test the capability of the Crew Health Care System as integrated in the ISS U.S. Laboratory.	1H5 Continue initial research on the International Space Station by conducting 6 to 10 investigations.	
Assessment		Green	TBD	

Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

	FY 1999	FY 2000	FY 2001	FY 2002
APG		0H9 Complete data reduction from the STS-95 Research Module mission. Begin to explore new cooperative efforts with NIH in the area of aging and transfer space-derived research for industry development of a new drug to treat Chagas' disease.	1H4 Conduct outstanding peer-reviewed and commercial research on STS-107 to advance knowledge in the fields of medicine, fundamental biology, biotechnology, fluid physics, materials processing and combustion	
Assessment		Green	TBD	
APG	H1 Support an expanded research program of approximately 800 investigations, an increase of ~9% over FY 1998. H2 Publish 90% of FY 1998 science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make it available on the Internet. H3 Establish a National Center for Evolutionary Biology with participation of at least 5 research institutions and engaging at least 20 investigators.	0H1 Support an expanded research program of approximately 935 investigations, an increase of ~17% over FY 1999. Publish 100 percent of science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make this available on the Internet.	1H3 Support an expanded, productive research community to include 975 investigations annually by 2001.	
Assessment	Green	Green	TBD	

Objective: Foster commercial research endeavors with the International Space Station and other assets.
Objective: Provide technical support for companies to begin space research.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H35 Increase non-NASA investment (cash and in-kind) in space research from $35M in FY96 to at least $50M in FY 1999, a 40% increase. H30 Complete the development of a commercialization plan for the ISS and Space Shuttle in partnership with the research and commercial investment communities and define and recommend policy and legislative changes. H36 Establish a new food technology Commercial Space Center.	0H47 Establish up to 2 new Commercial Space Centers. 0H49 Foster the establishment of a telemedicine hub in Western Europe. NASA and CNES will develop an international telemedicine program to incorporate and connect existing medical informatics capabilities into a user-friendly commercial electronic telemedicine hub and apply lessons learned to human space flight. 0H46 Utilize at least 30% of Space Shuttle and ISS FY 2000 capabilities for commercial investigations, per the U.S. Partner Utilization Plan.	1H23 Foster commercial endeavors by reviewing and/or implementing new policies and plans such as the Space Station resource pricing policy and intellectual property rights policy. Ensure that Space Station resources allocated to commercial research are utilized by commercial partners to develop commercial products and improve industrial processes. 1H22 Establish at least ten new, active industrial partnerships to research tomorrow's space products and improve industrial processes through NASA's Commercial Space Centers, and find opportunities for space experiments.	2B11 Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators.
Assessment	Green (H35, H36); Yellow (H30)	Green	TBD	TBD

Objective: Systematically provide basic research knowledge to industry.

APG				2B12 Highlight ISS-based commercial space research at business meetings and conferences.
Assessment				TBD

Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H37 Initiate a curriculum development program, in partnership with the International Technology Education Association (ITEA), for gravity related educational modules for national distribution which meet the current National Science Teachers Association (NSTA) National Standards for Science for Grades K-12, and the ITEA National Standards for Technology Education to be published June 1999. H39 Conduct at least two demonstrations of the applicability of the "Telemedicine Instrumentation Pack" for health care delivery to remote areas. H40 Demonstrate the application of laser light scattering technology for early detection of eye-tissue damage from Diabetes; publish results in peer-reviewed open literature.	0H56 The NASA-Sponsored National Space Biomedical Research Institute will conduct an open symposium relaying the results of space-oriented research activities focusing on up to 10 ground-related applications with the participation of interested investigators; publish results in a conference proceedings report.	1H26 Support participation in HEDS research.	2B13 Provide information and educational materials to American teachers.
Assessment	Green	Green	TBD	TBD

Objective: Engage and involve the public in research in space.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H38 Expand the microgravity research program's World Wide Web-based digital image archive established in 1998 by 50%.			2B14 Work with media outlets and public institutions to disseminate OBPR information to wide audiences.
Assessment	Green			TBD

Biological and Physical Research Enterprise FY 2002	Advanced Human Support Technology	Biomedical Research & Countermeasures	Fundamental Space Biology	Physical Sciences Research	Space Product Development	Mission Integration	Health Research
2B1: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Identify and test biomedical countermeasures that will make space flight safer for humans. Identify and test technologies that will enhance human performance in space flight.		X					
2B2: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Identify and test new technologies to improve life support systems for spacecraft.	X						
2B3: Earn external review rating of "green" or "blue" by making progress in the following research focus areas: Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring. Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers.			X	X			
2B4: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Advance the scientific understanding of complex biological and physical systems.				X			
2B5: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.				X			
2B6: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology.				X			

Biological and Physical Research Enterprise FY 2002	Advanced Human Support Technology	Biomedical Research & Countermeasures	Fundamental Space Biology	Physical Sciences Research	Space Product Development	Mission Integration	Health Research
2B7: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.				X			
2B8: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Investigate fundamental and unresolved issues in fluid physics, and materials and combustion sciences using gravity as a theoretical and experimental revealing tool.				X			
2B9: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Understand the role of gravity in biological processes at all levels of biological complexity.			X				
2B10: In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.	X	X	X	X	X	X	
2B11: Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators.					X		
2B12: Highlight ISS-based commercial space research at business meetings and conferences.					X		
2B13: Provide information and educational materials to American teachers.	X	X	X	X	X	X	
2B14: Work with media outlets and public institutions to disseminate OBPR information to wide audiences .	X	X	X	X	X	X	